RFQ couplers test stand

S. Kazakov

01/14/2014

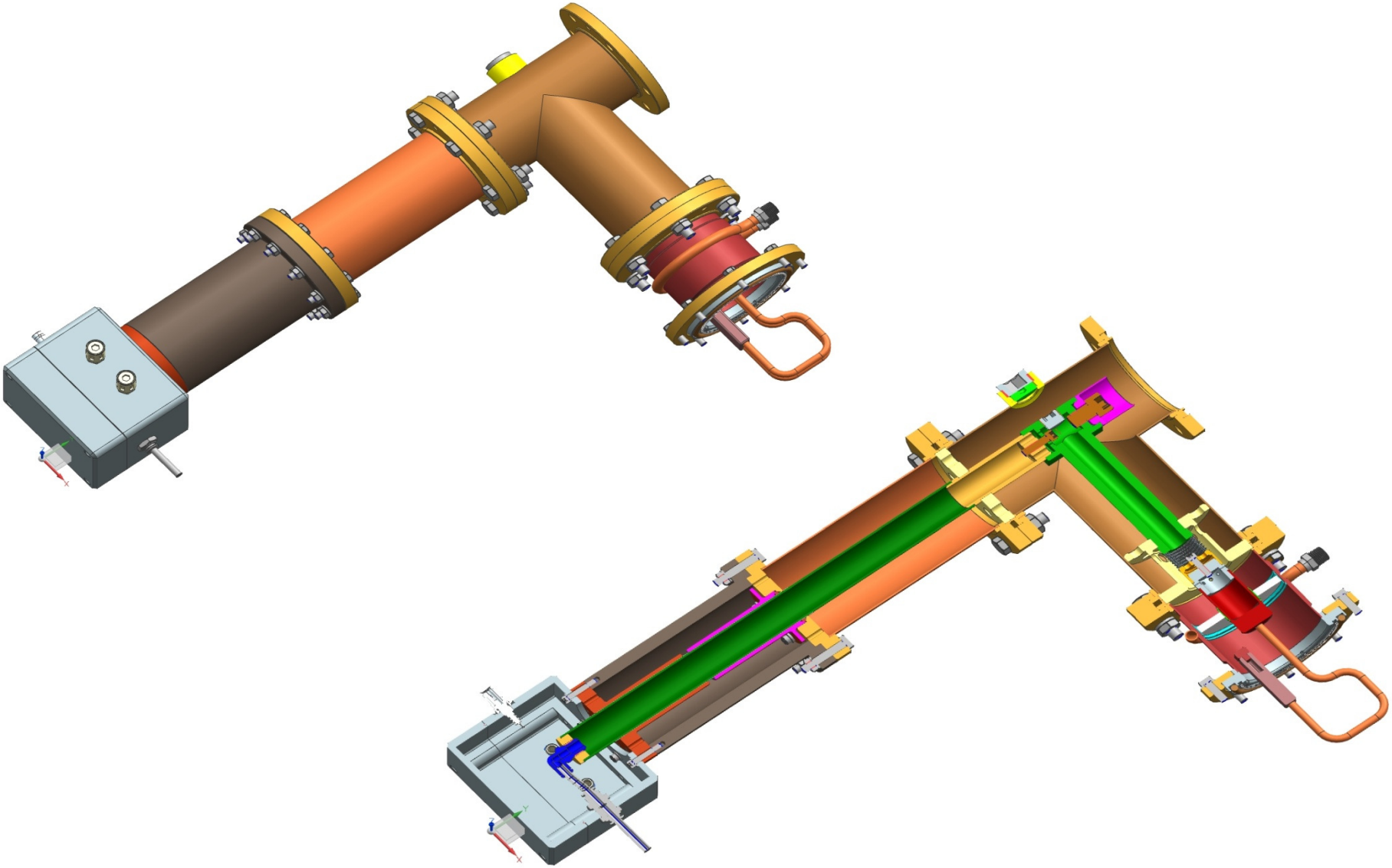
Requirements

RFQ parameters (from RFQ FRS)

Parameter	Value
Ion type	H-
Beam current	1-10 mA
Beam input energy	0.03 keV
Beam output energy	2.1 MeV
Frequency	162.5 MHz
Duty factor (CW)	100%
Total RF power	≤ 130 kW
Number of couplers	2

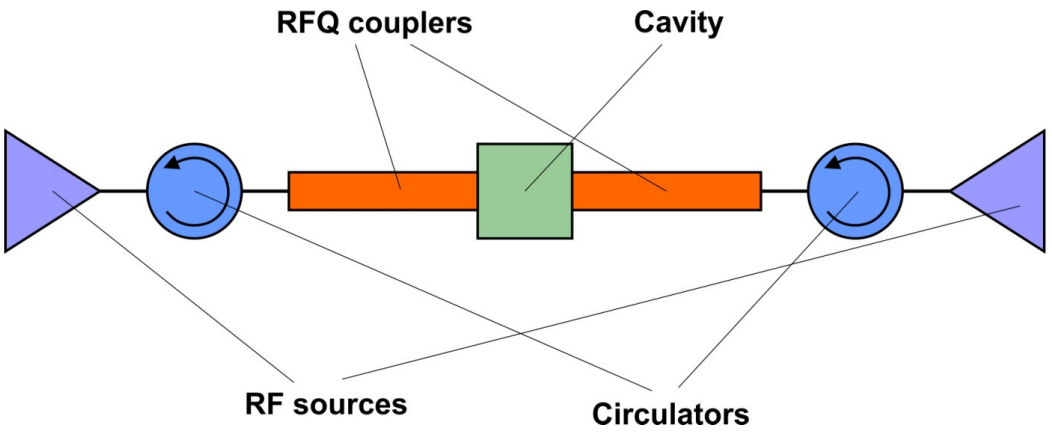
Coupler requirements

Parameter	Value
Frequency	162.5 MHz
Operating power (SWR: $1 \div \infty$)	75 kW
Coupling type	Loop
Output port diameter	~3"
Input impedance	50 Ohm



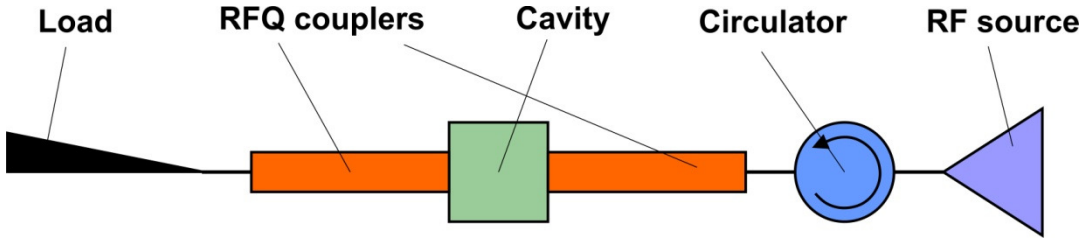
Documentation is ready for bidding . We can hope to have couplers in half of year.

Possible configurations of test



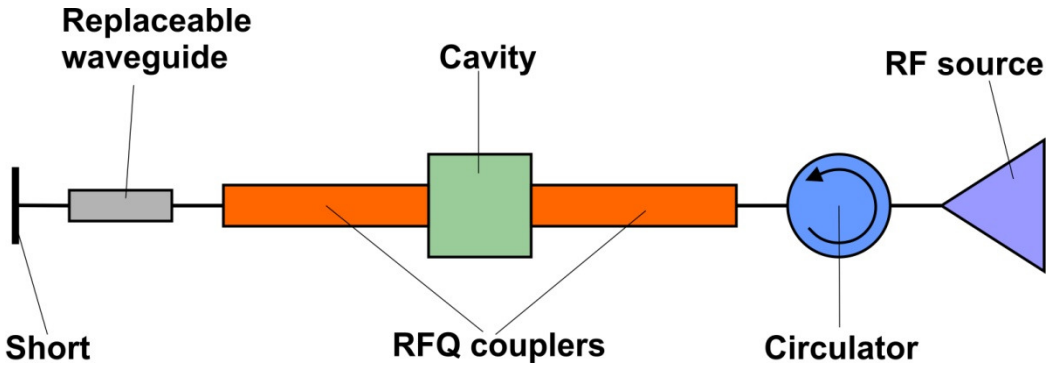
Two RF sources

Couplers can be test in TW and SW modes with any phase of reflected power.



One RF source

TW mode



SW mode

Choosing of coupling cavity

Two approach is possible:

1. Make a model of RFQ cavity (one quarter)

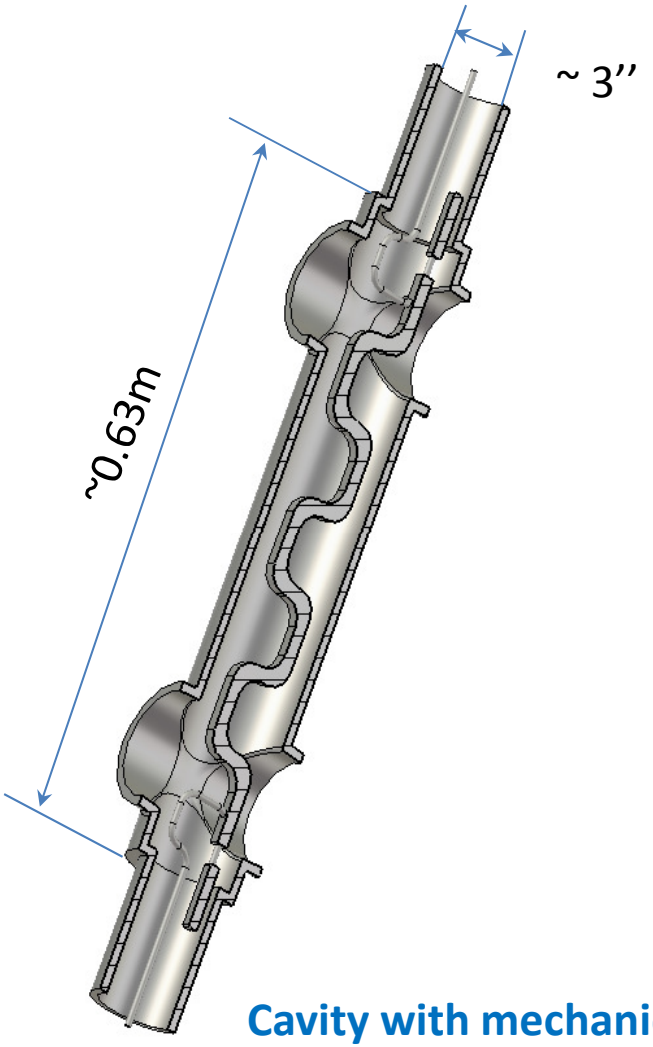
Pros: couplers will be tested close to operating conditions.
Cons: big size of cavity (~ 1m), narrow bend (tuning mechanism is needed), not clear issue with multipactor - expensive.

2. Make cavity as simple is possible.

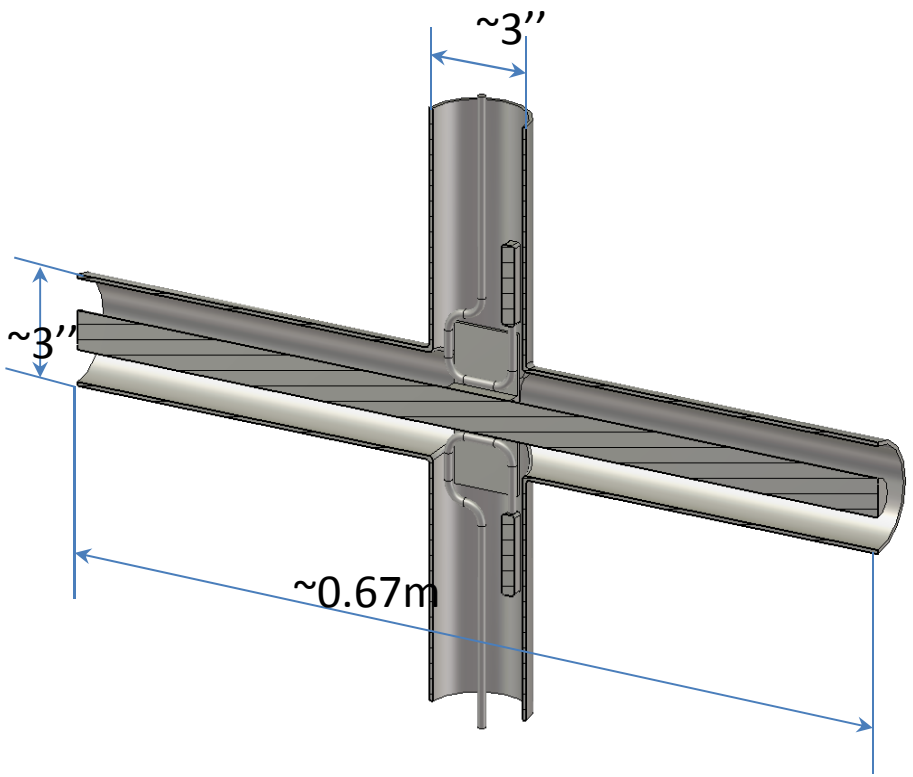
Pros: less expensive, can control / suppress multipactor.
Cons: fields around coupling loop is different from operating fileds.
Only geometry before loop can be tested (ceramic window, etc.).
We cannot test loop cooling.

We chose second approach.

Several options were investigated:

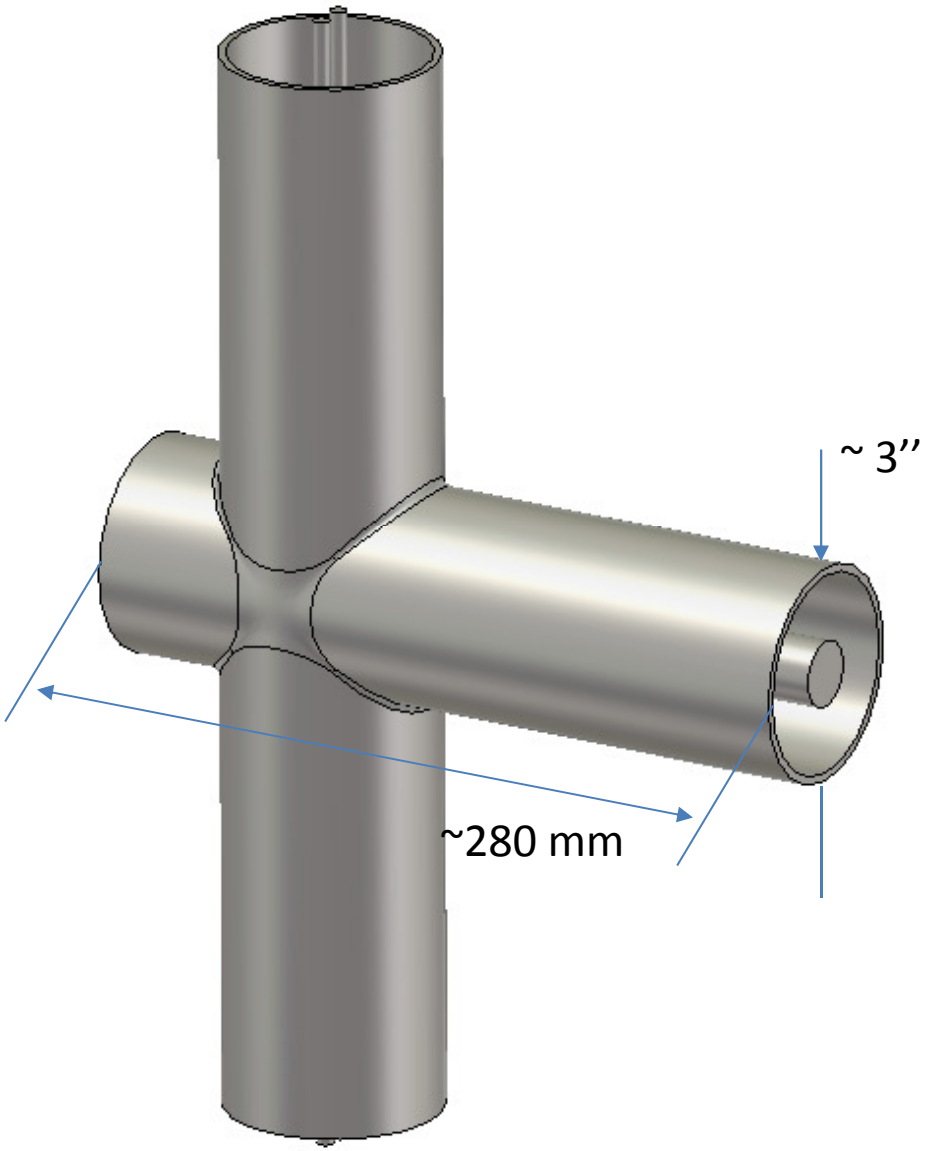


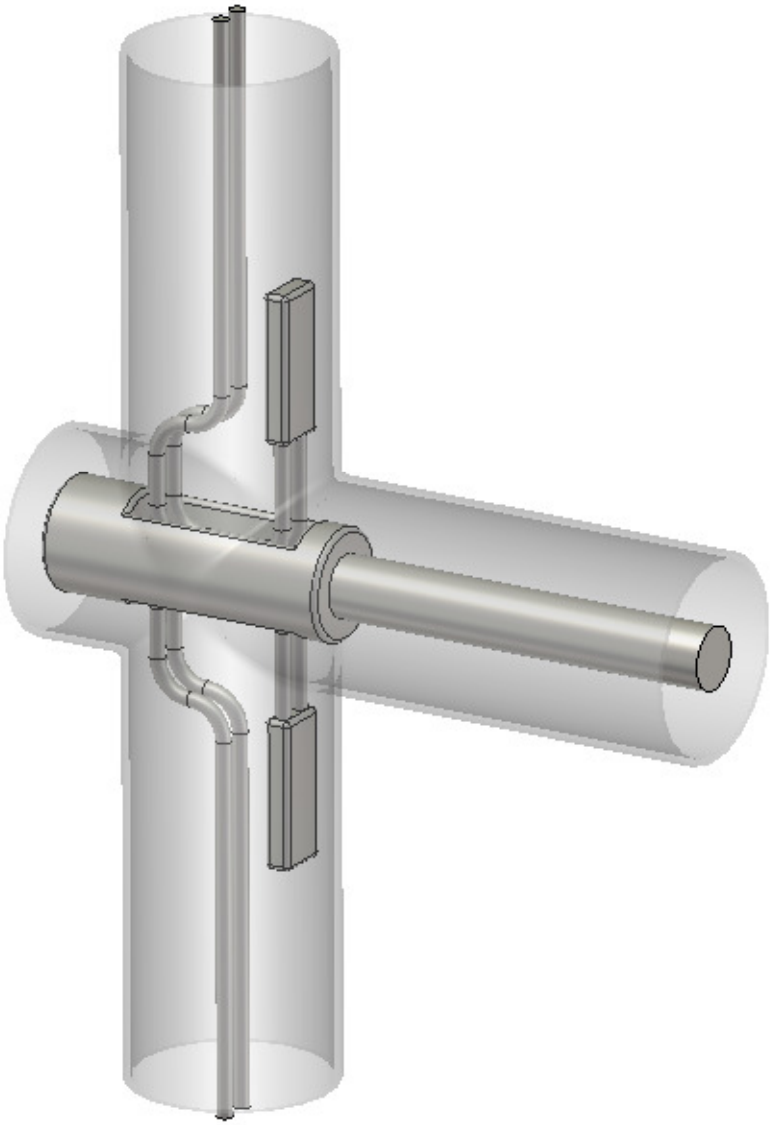
Cavity with mechanical contact between loops



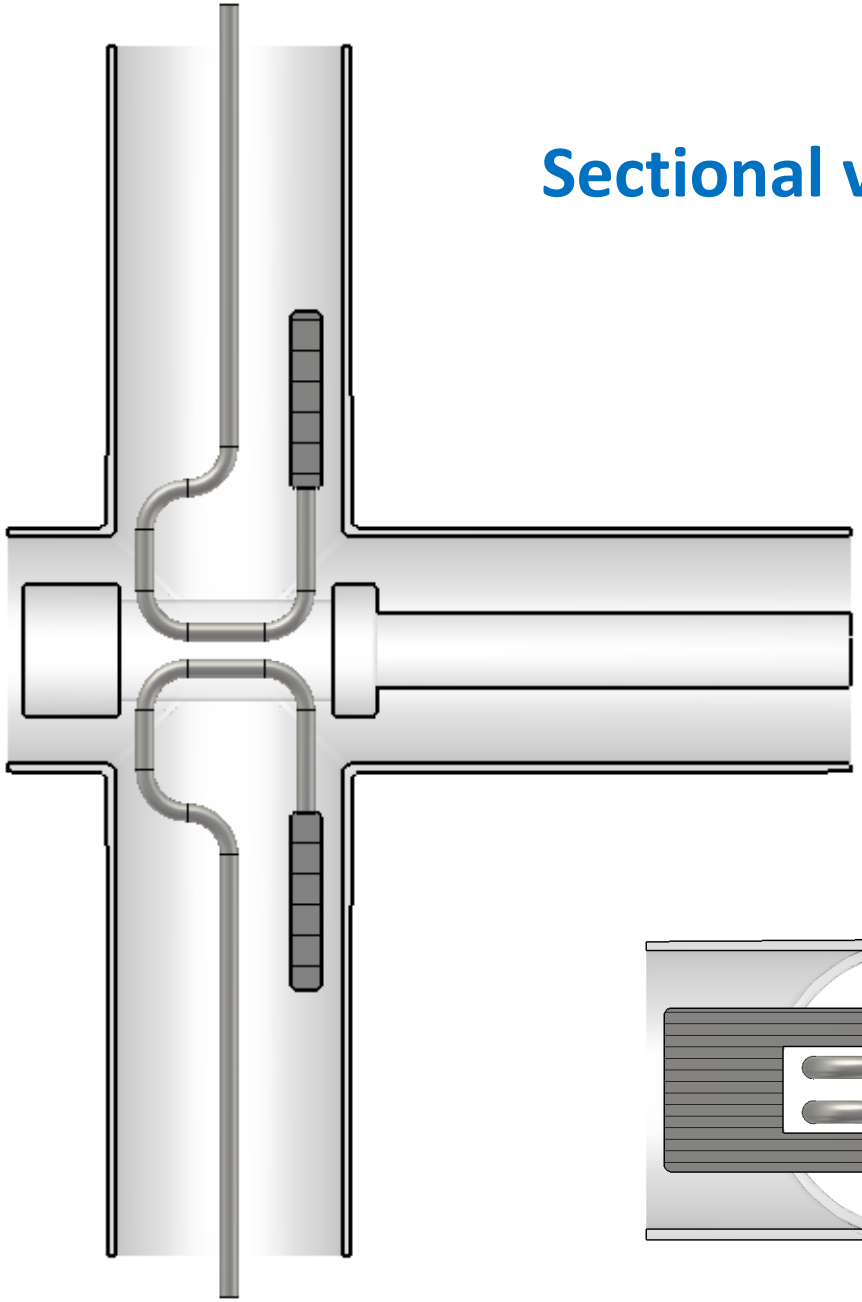
Cavity without mechanical contact between loops

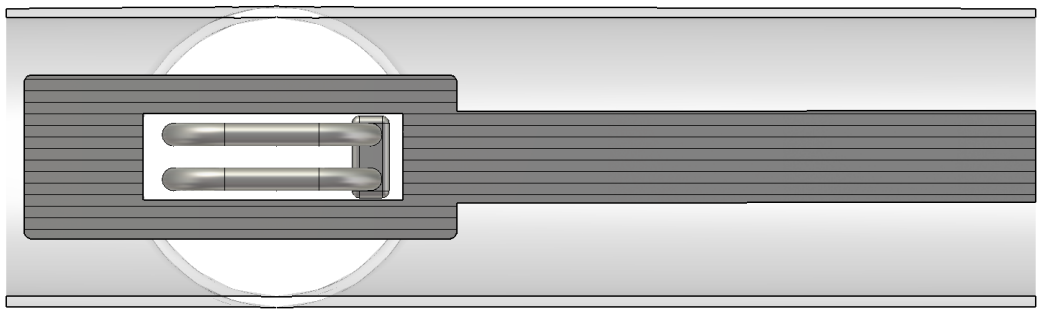
The chosen geometry



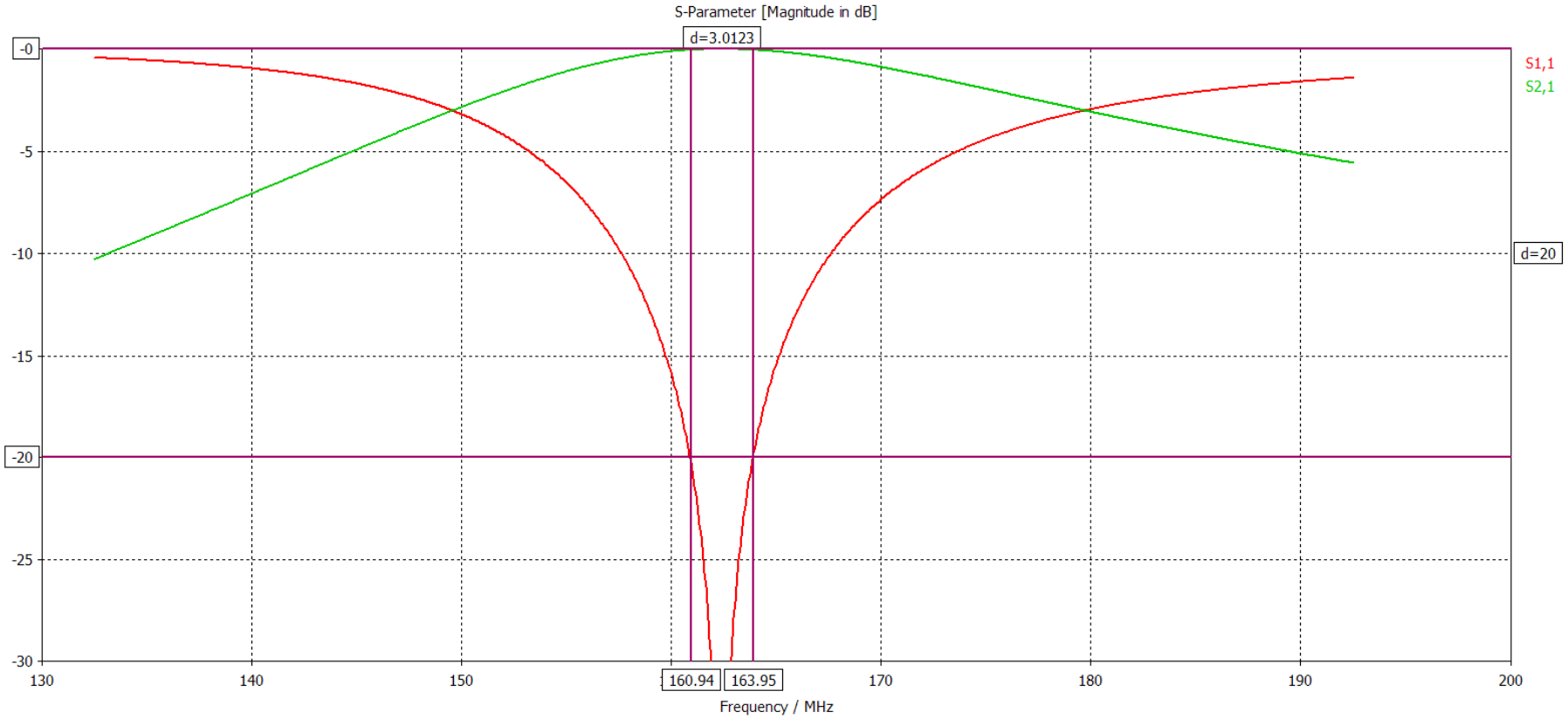


Sectional views of coupling cavity



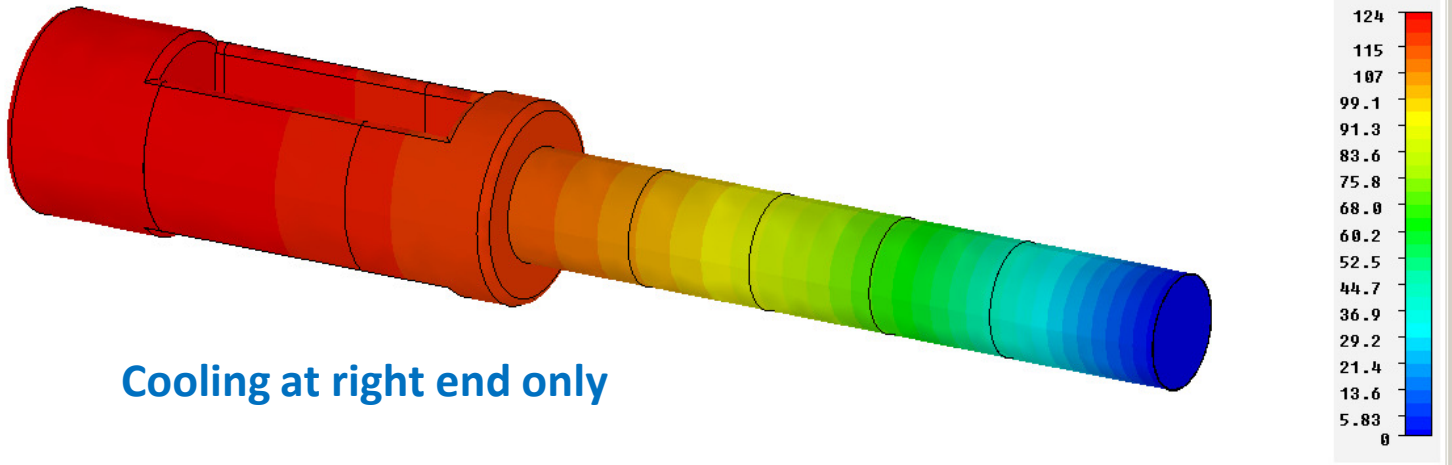


Passband of coupling cavity

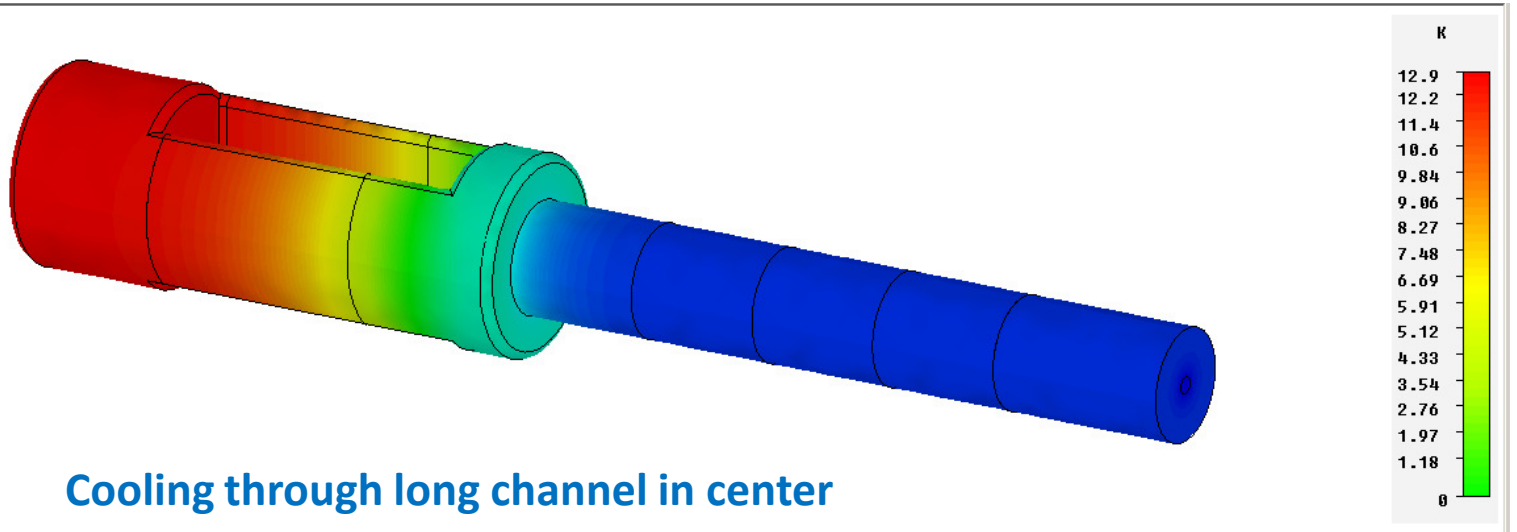


Q = 5.4

Temperature rise estimation. P ~ 232W



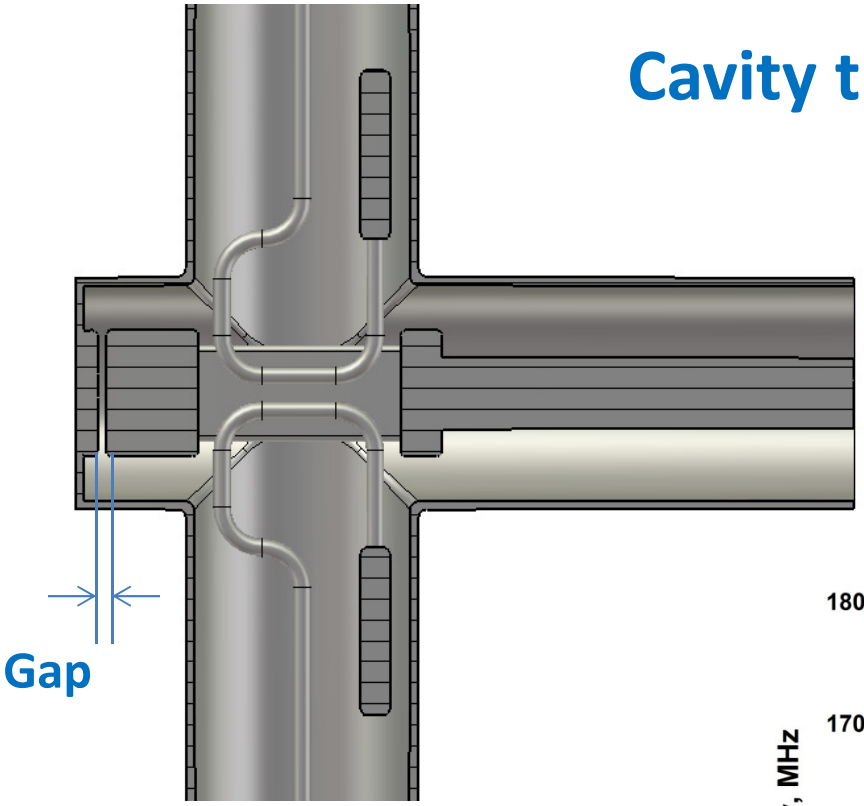
Cooling at right end only

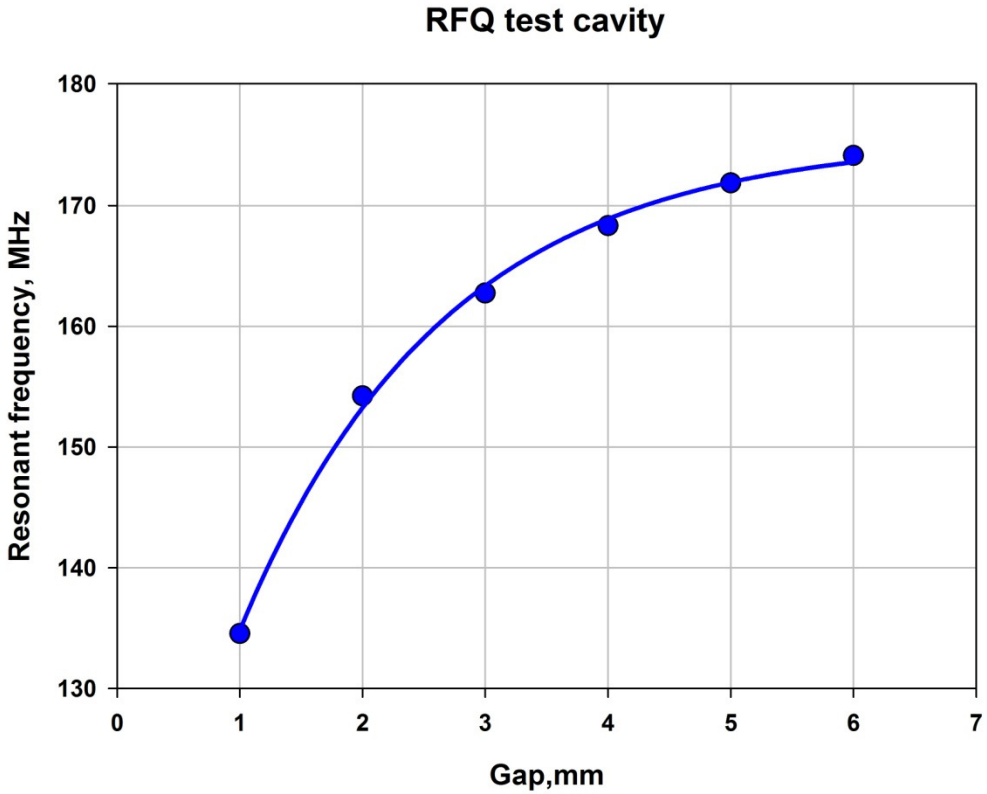


Cooling through long channel in center

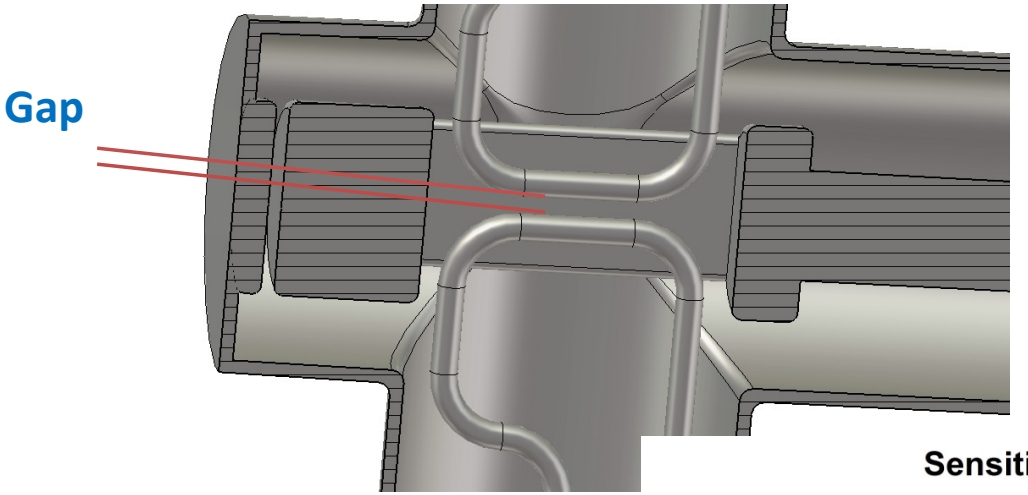
Water cooling: flow ~ 70 -100 g/s, dT (max – water T) ~ 40 C

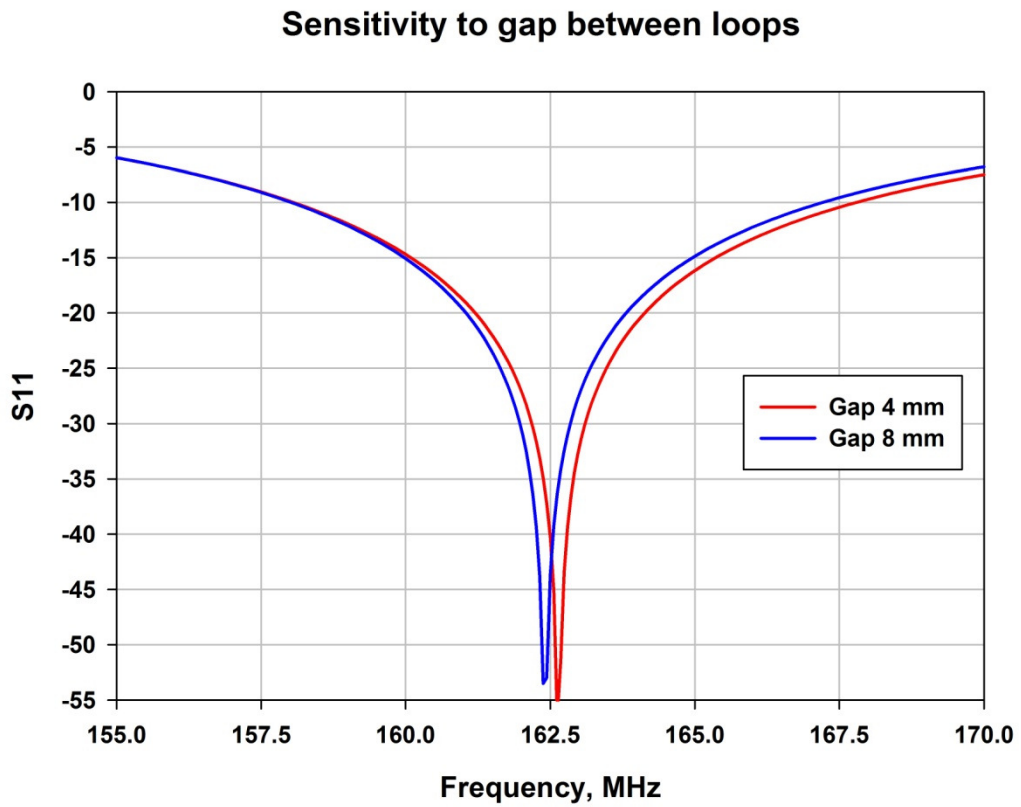
Cavity tuning by gap size changing.





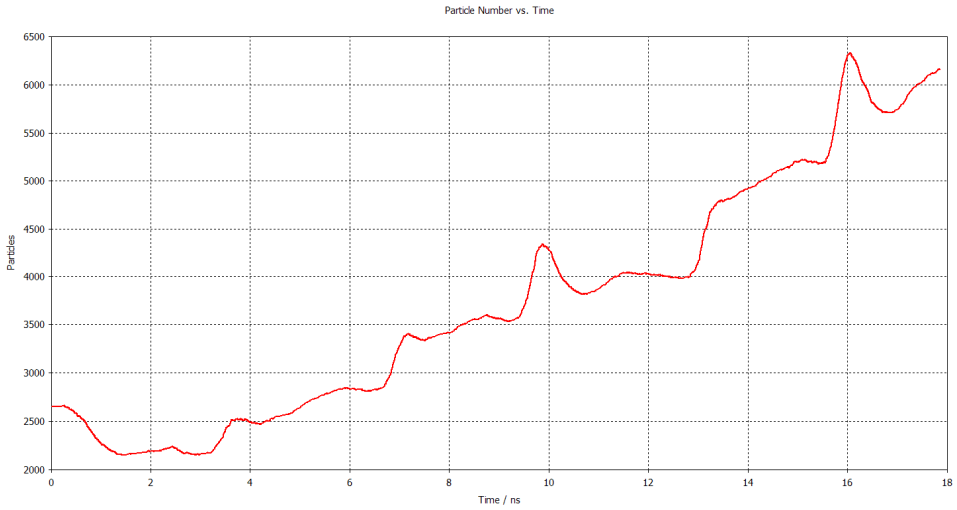
Sensitivity to the gap between loops

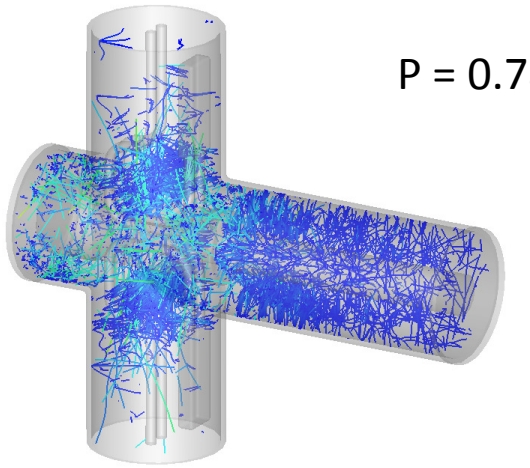




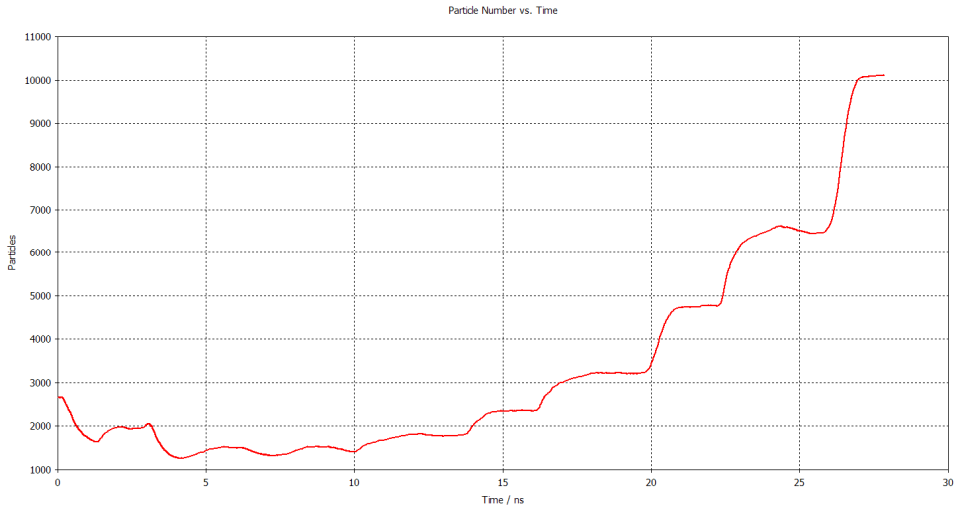
Resonant frequency is not sensitive to gap size

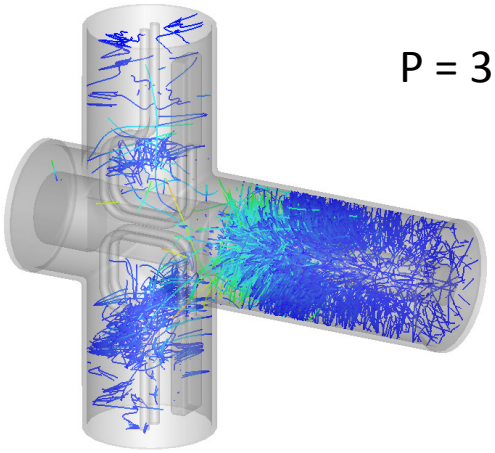
Multipacvtor in the cavity





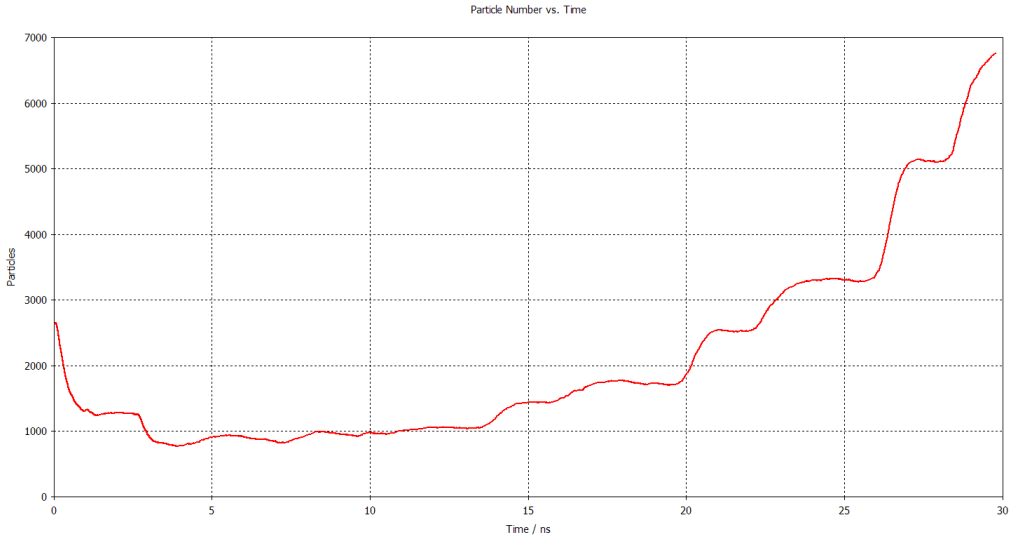
P = 0.78 KW

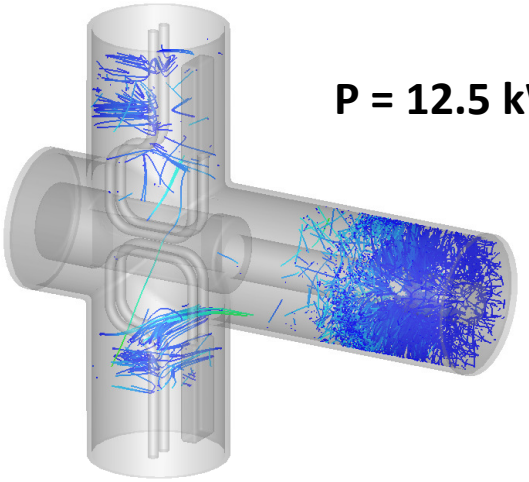




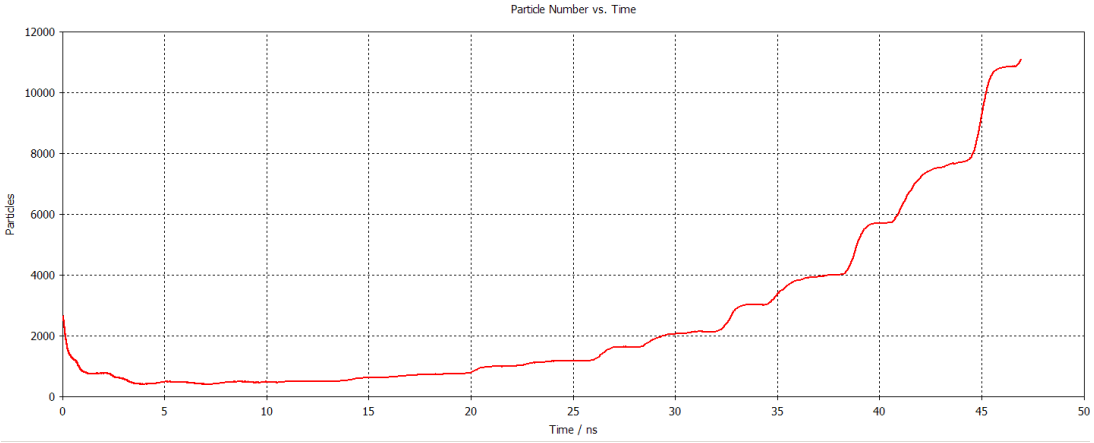
P = 3.1 KW

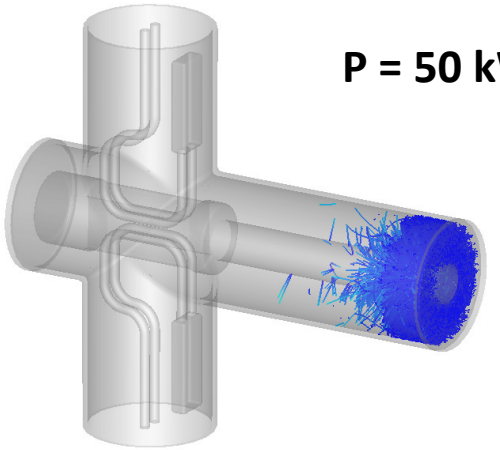
For interesting range of power
the multipactor is localized in coaxial end.





P = 12.5 kW

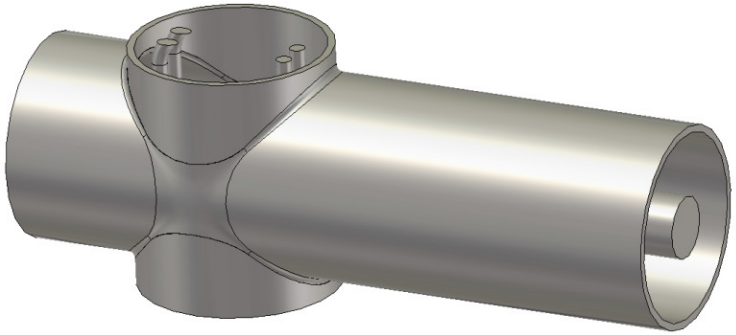


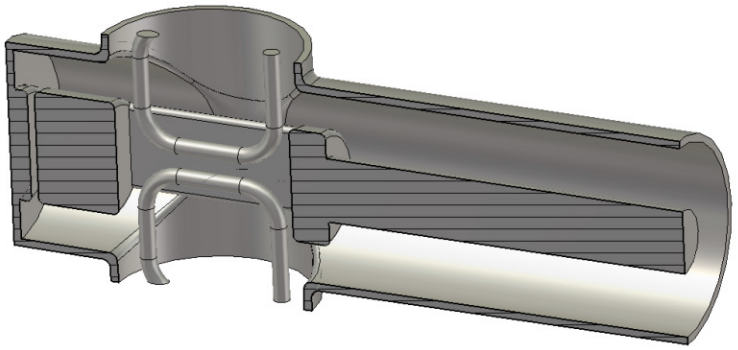


P = 50 kW

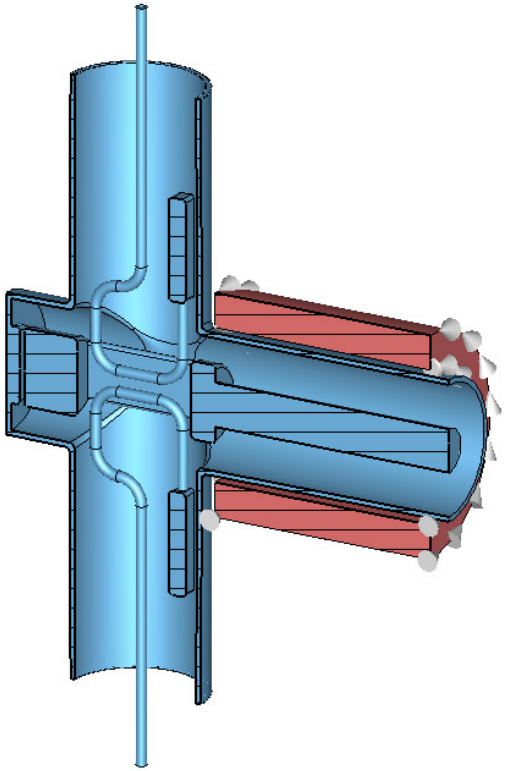
Multipactor can be suppressed by magnetic field

Geometry for multipactor simulations:

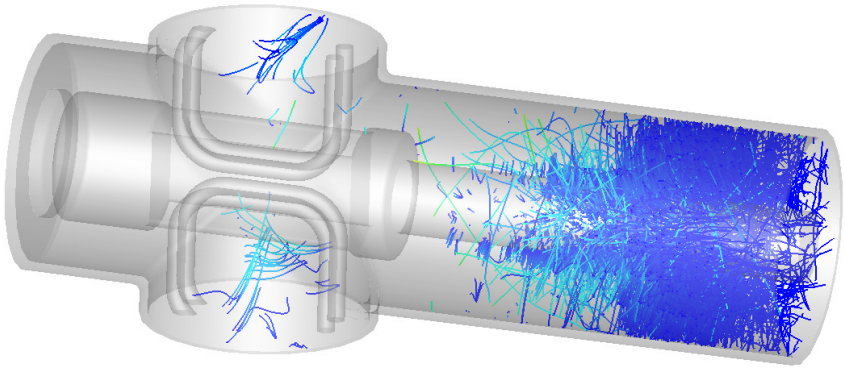


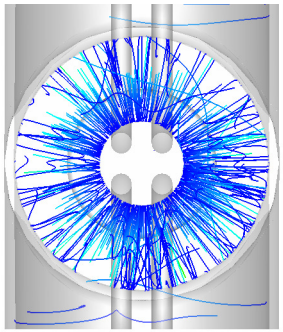


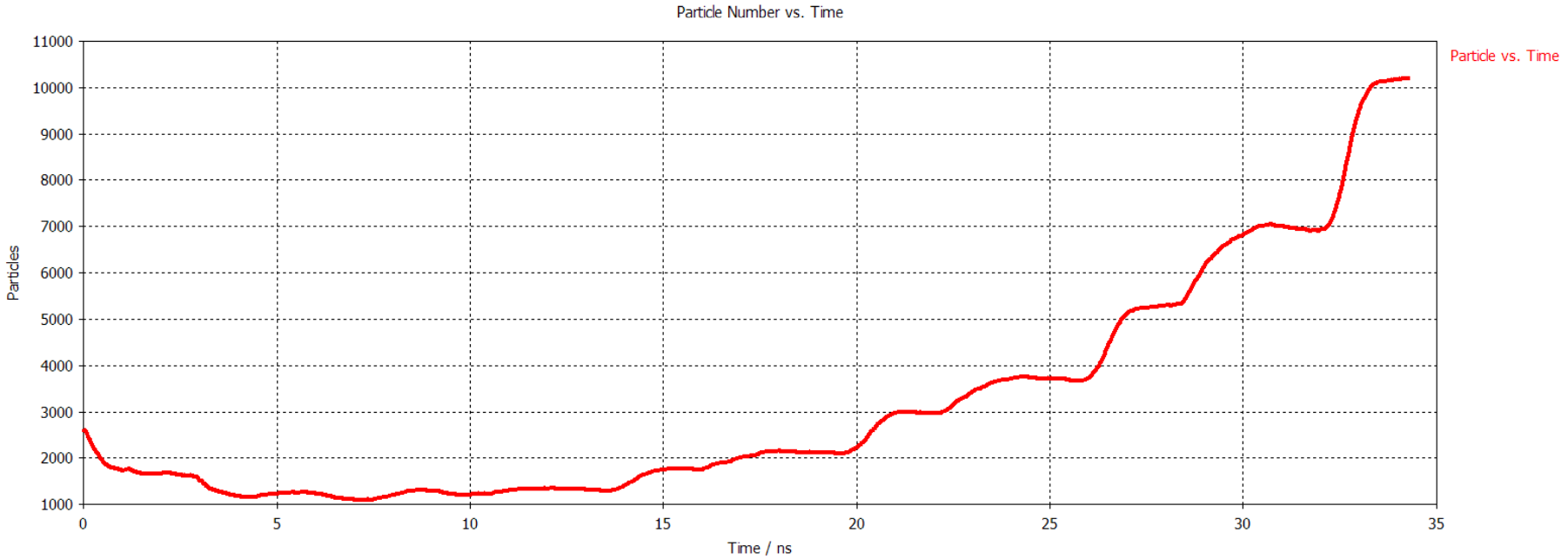
Geometry for magnetic field calculation:



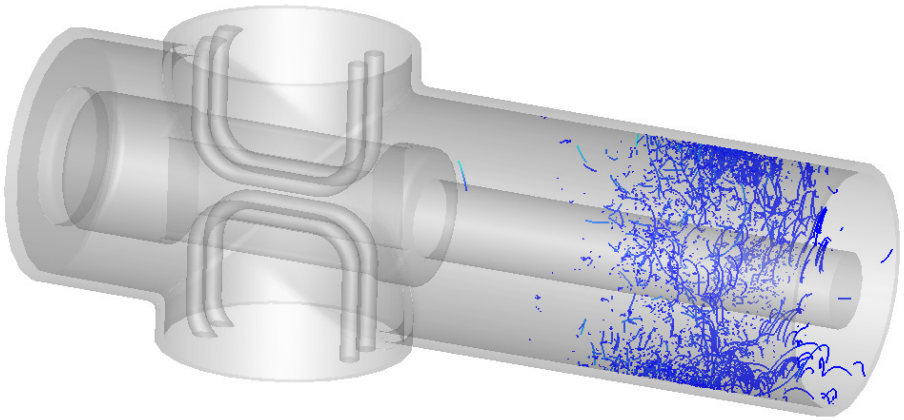
RF = 12.5 kW Solenoid -> 0 A x turn

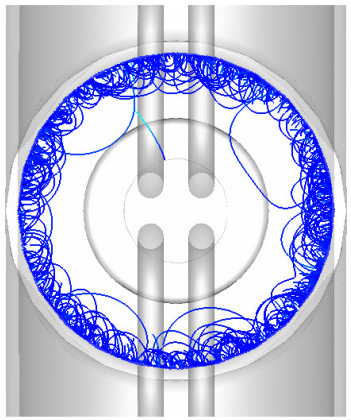


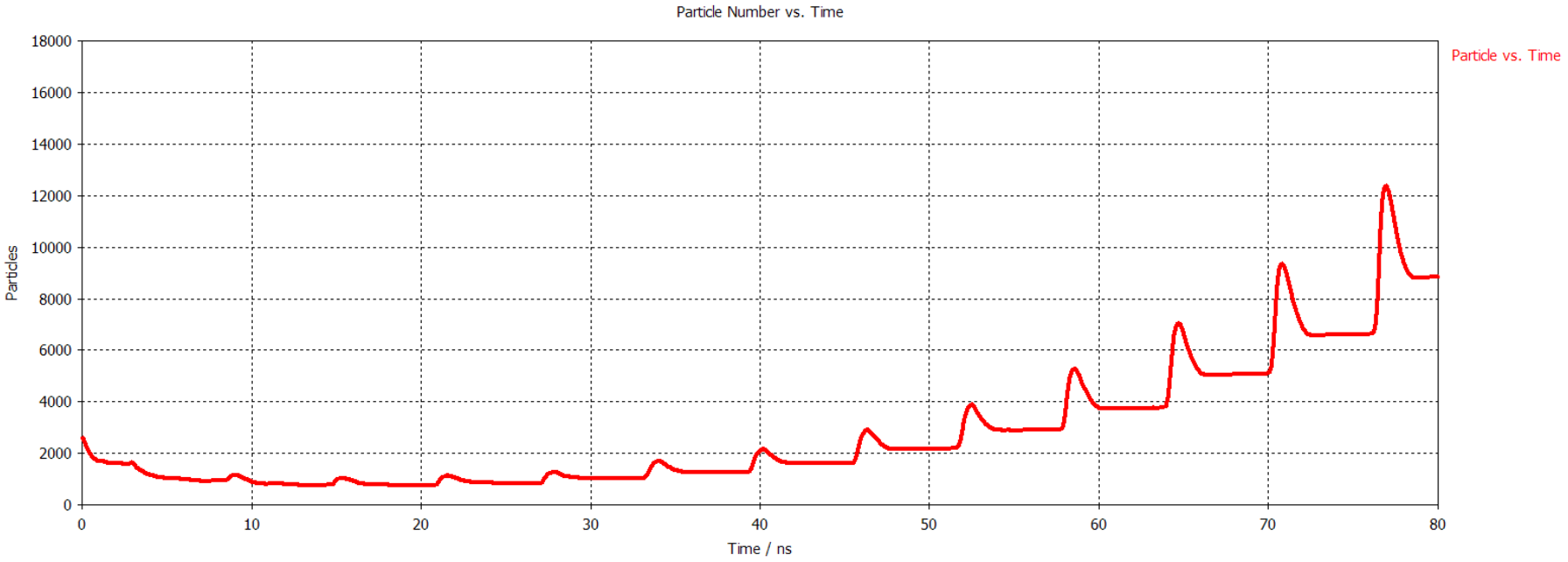




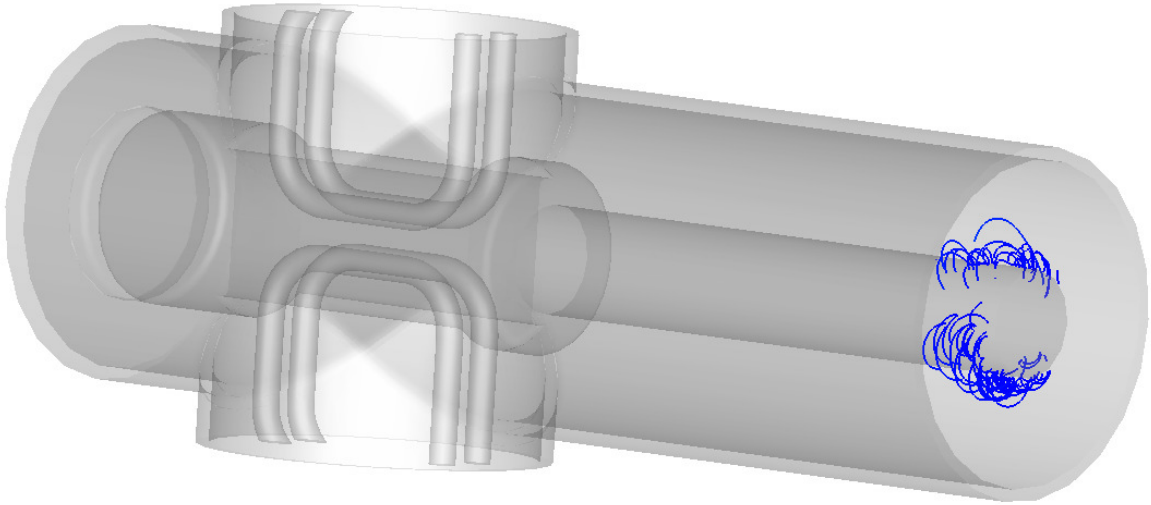
RF = 12.5 kW Solenoid -> 790 A x turn

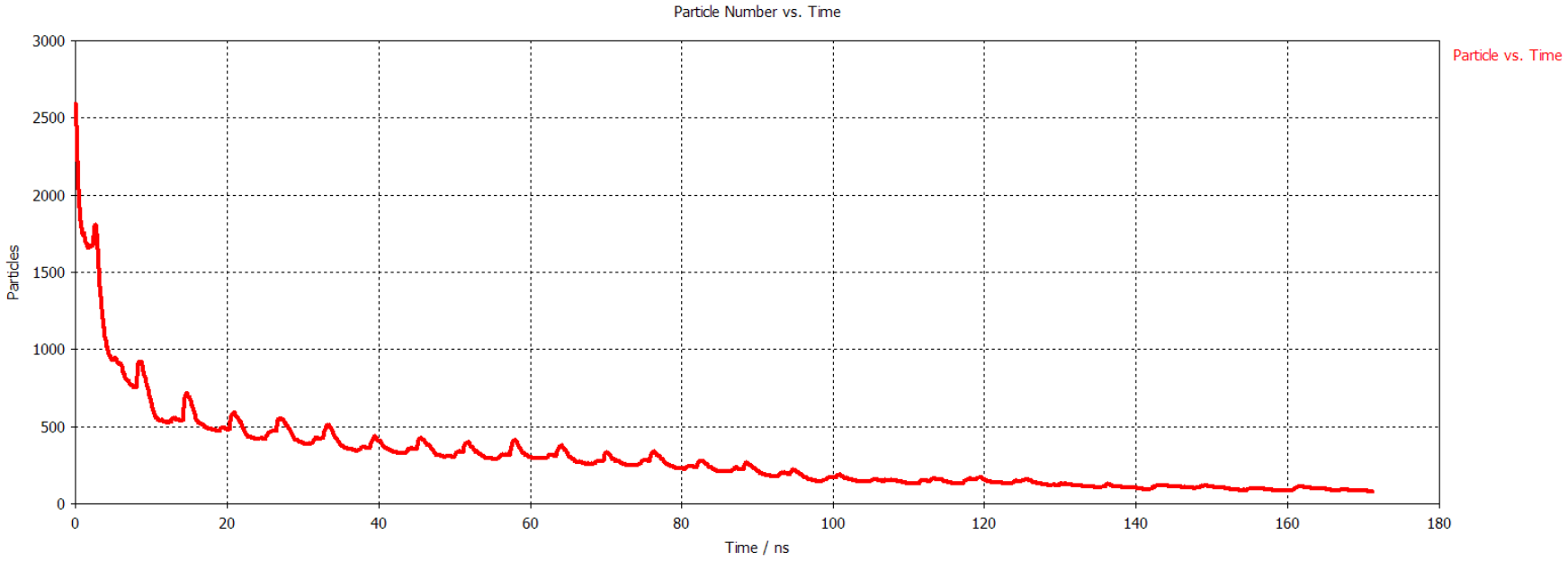




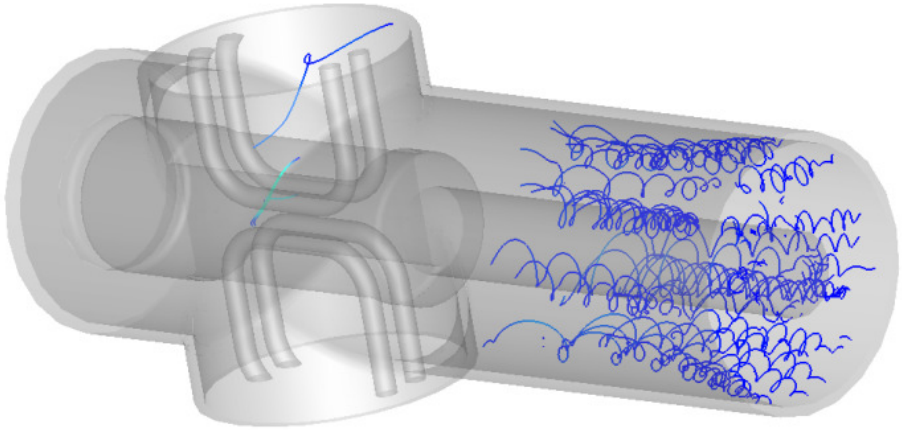


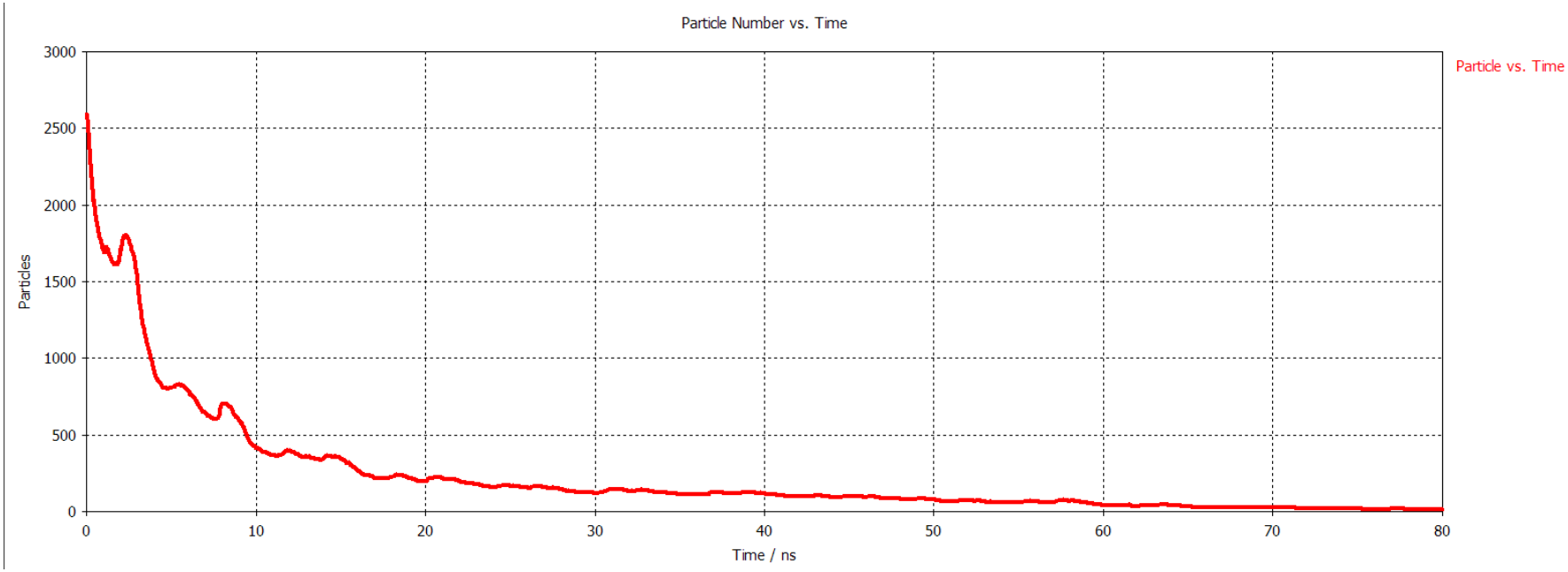
RF = 12.5 kW Solenoid -> 1185 A x turn



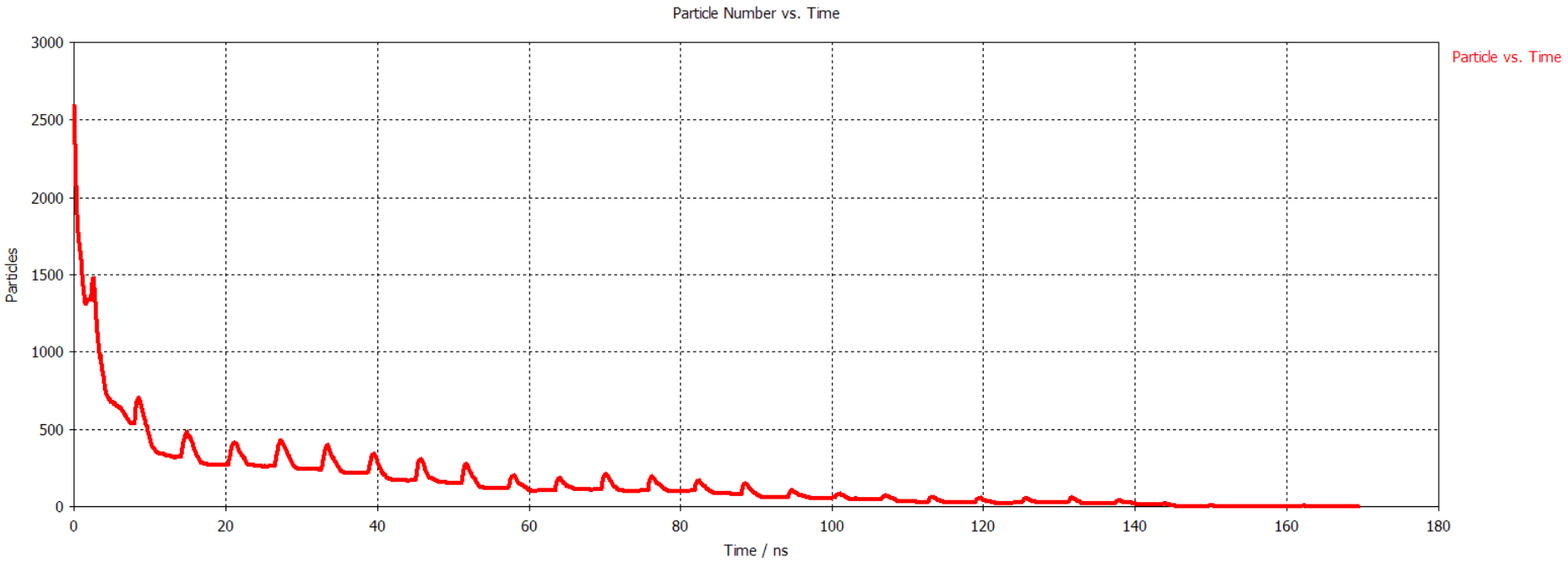


RF = 12.5 kW Solenoid -> 1580 A x turn

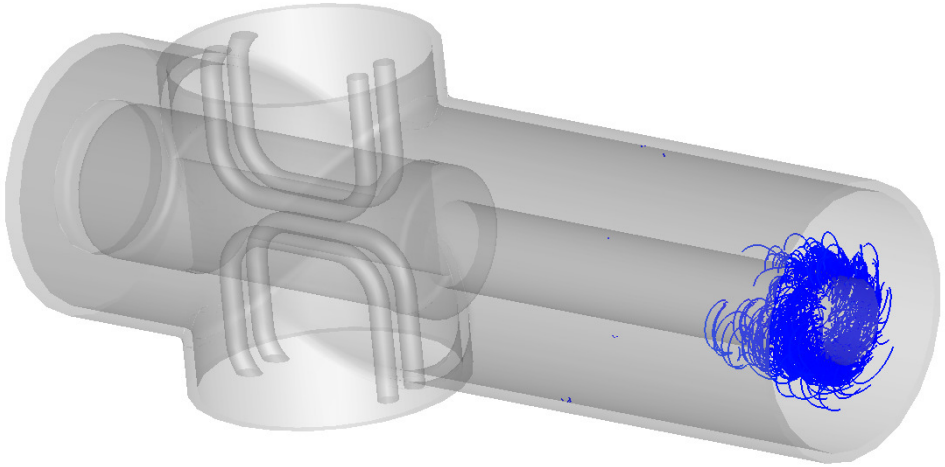


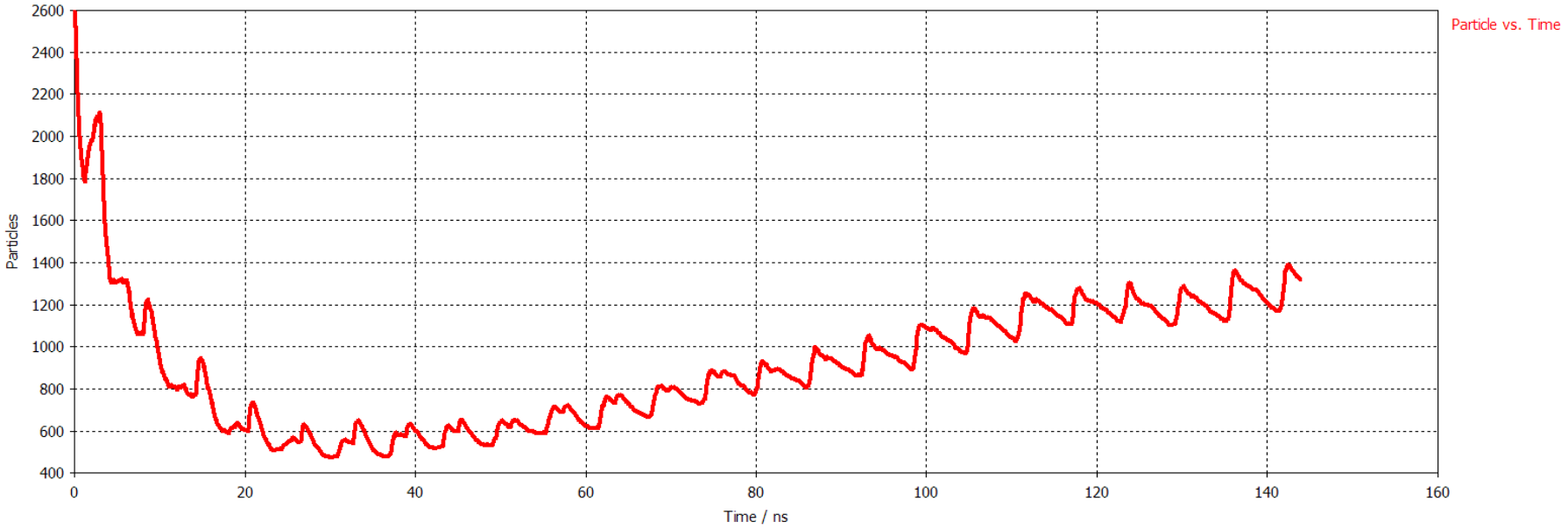


RF = 25 kW Solenoid -> 1185 A x turn

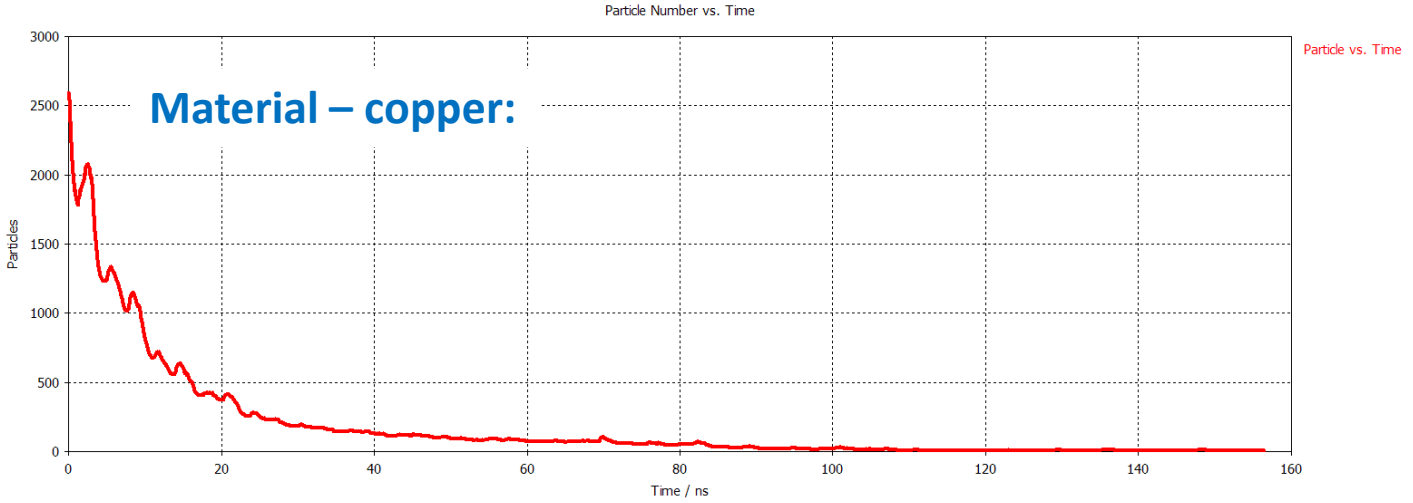


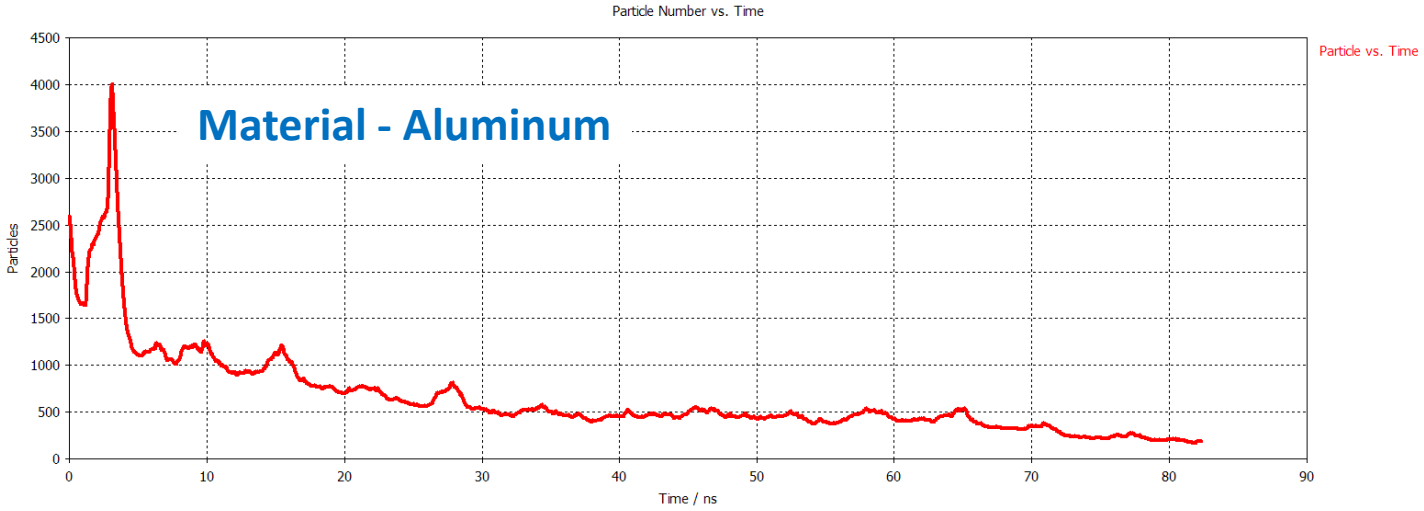
RF = 6.5 kW Solenoid -> 1185 A x turn





RF = 6.5 kW Solenoid -> 1580 A x turn



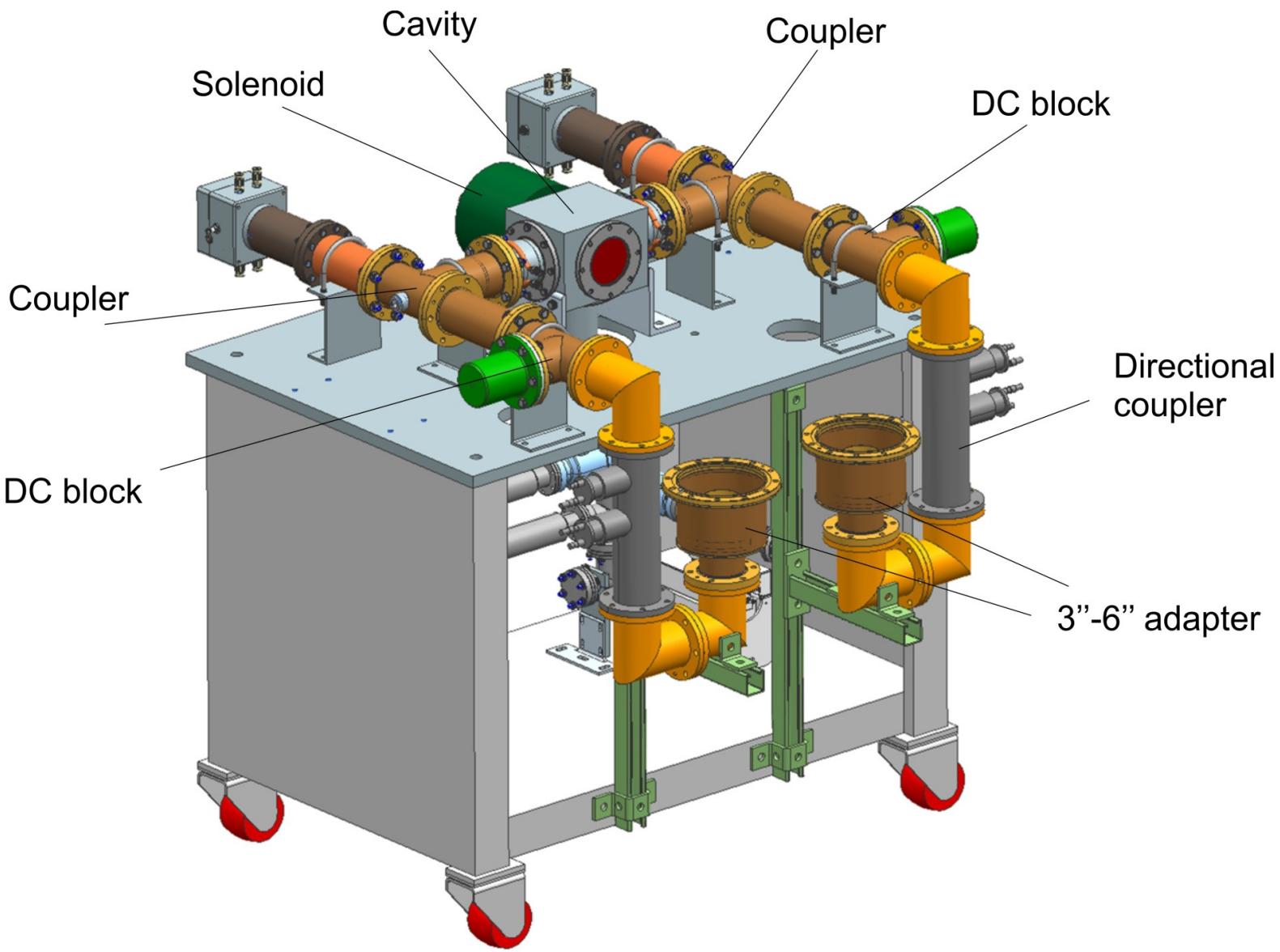


Conclusion:

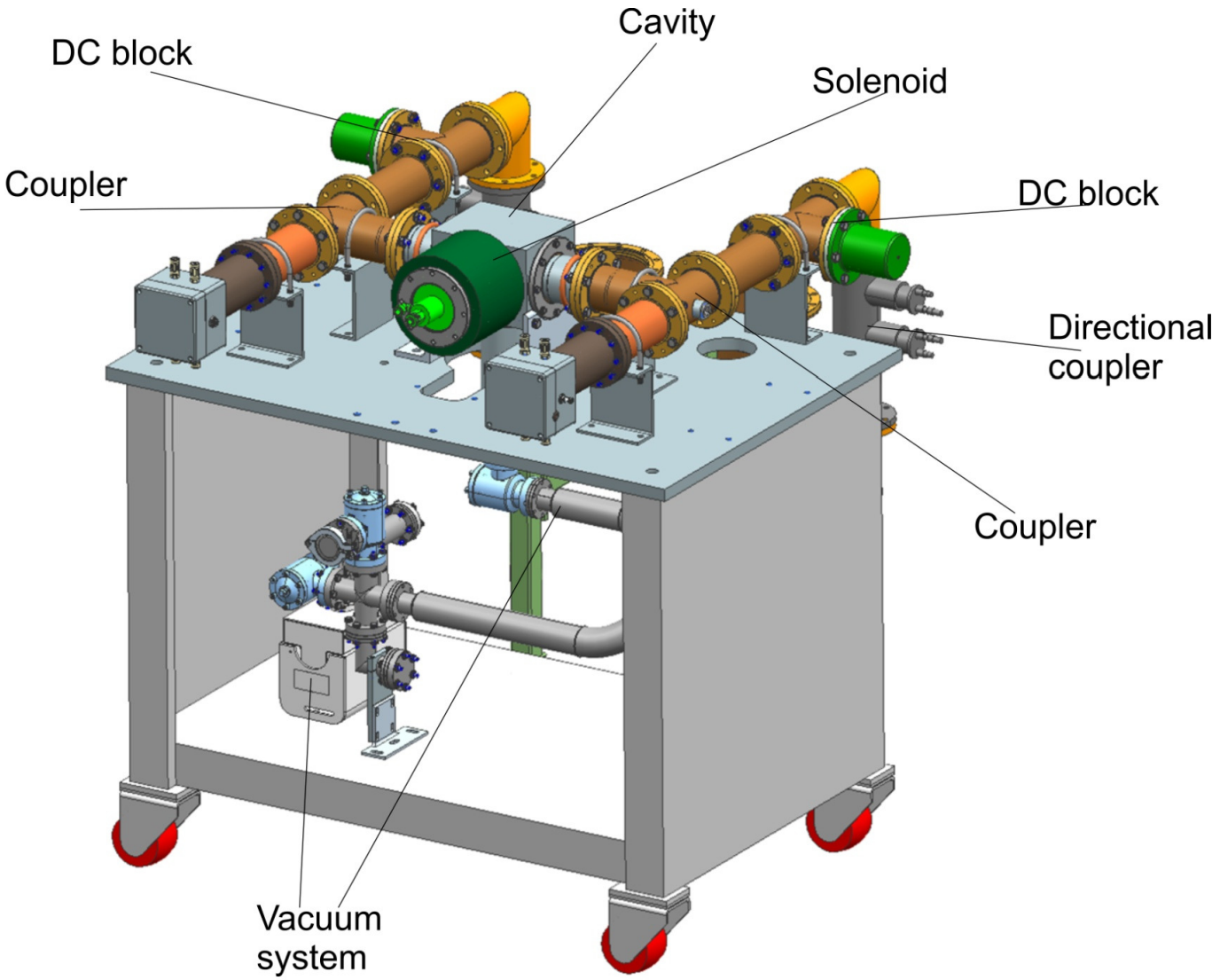
Solenoid with ~ 2000 A x turn will suppress multipactor in coaxial part of cavity.

(H ~ 1.4E+4 A/m, ~ 0.017 T)

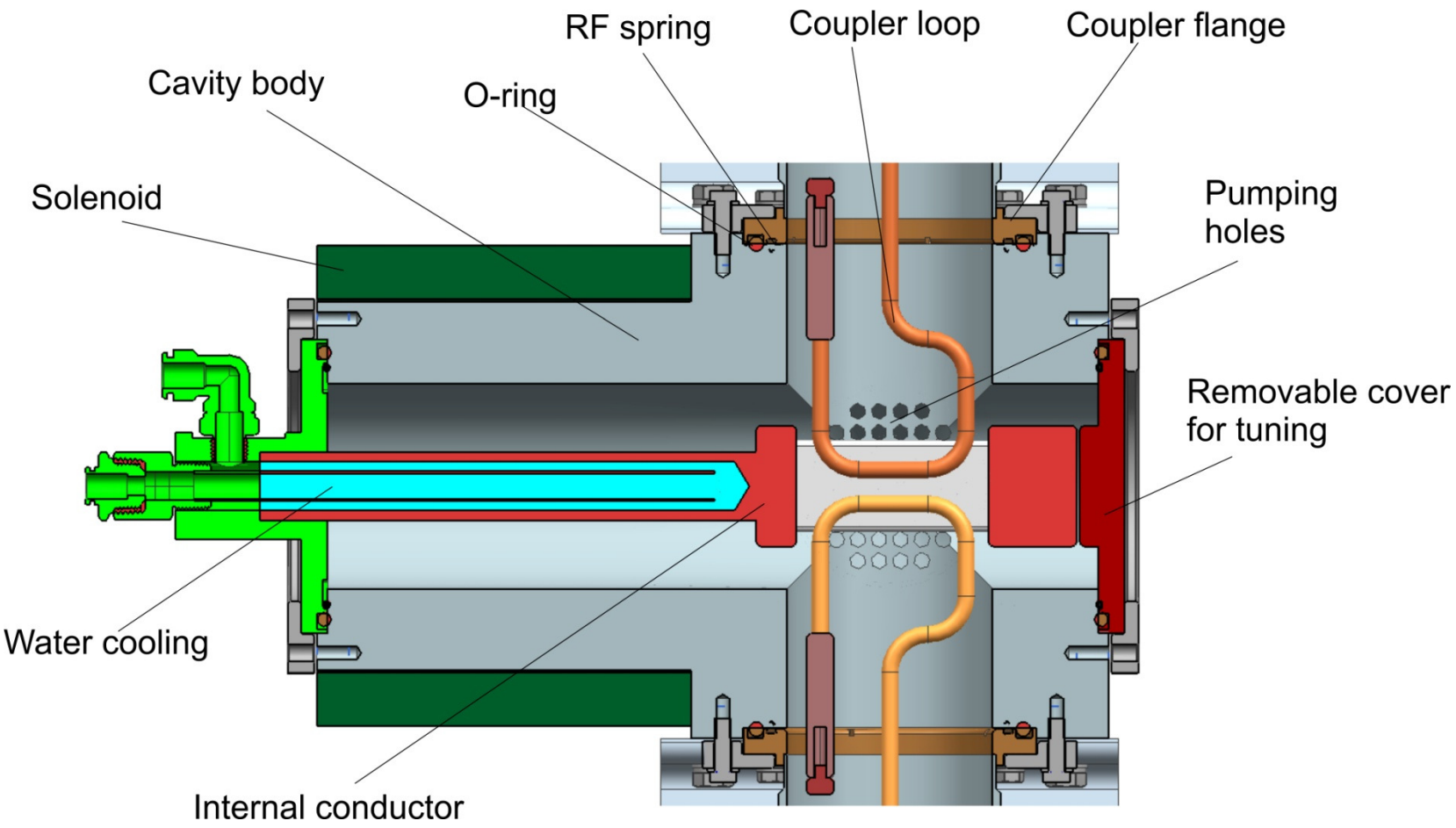
3-D model of RFQ coupler test stand



3-D model of RFQ coupler test stand



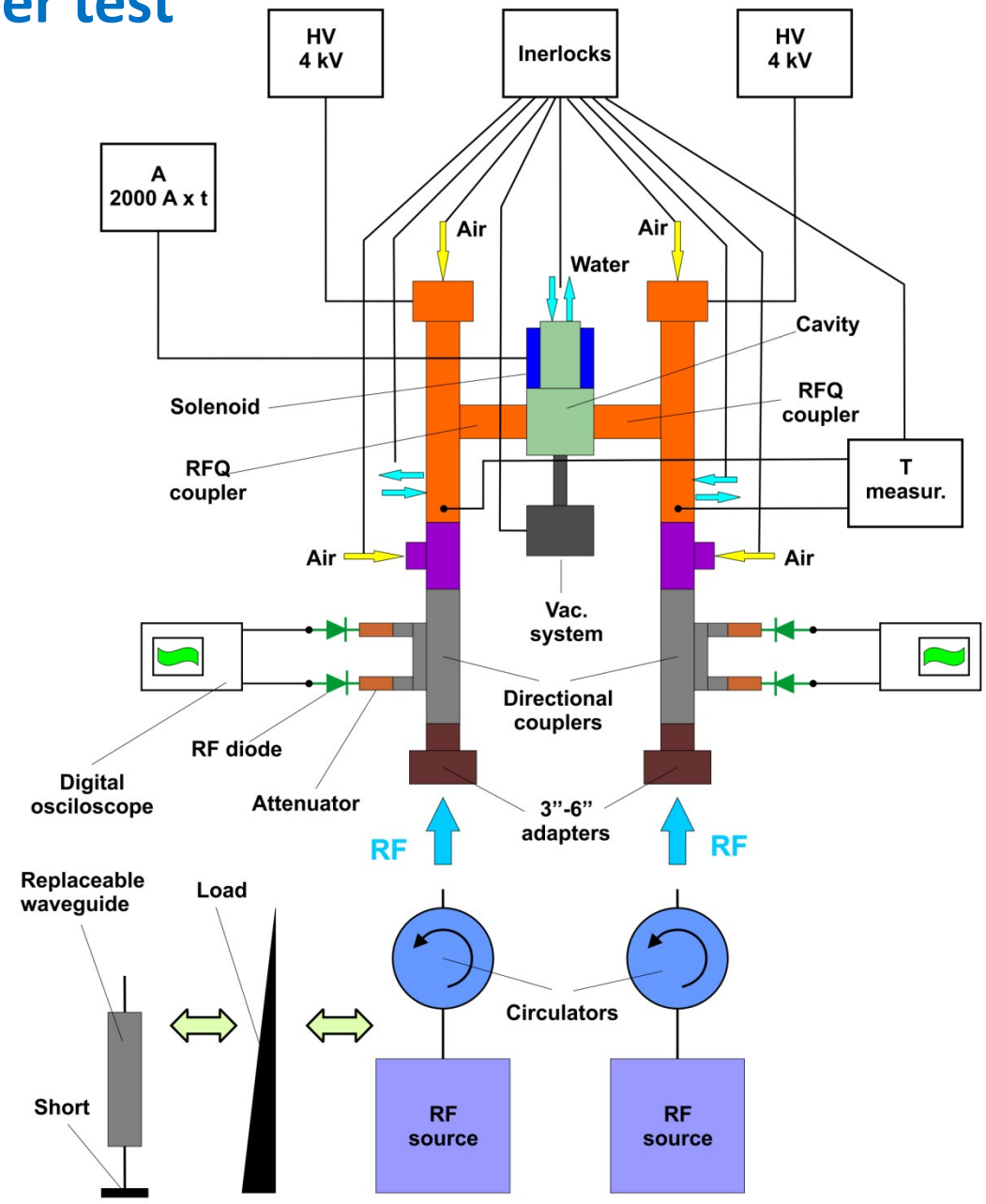
Coupling cavity



Block diagram of RFQ coupler test

Control signals:

- Direct / Reflected RF power
- Temperature around window
- Vacuum level



WWW.

Questions we have to answer:
When? Where? Who?

When:
We expect that couplers will be produced within 0.5 year. In nearest days documentation will be ready for bidding. DC blocks are under production. Test stand (test cavity) can be produced within 3-4 months. It seems infrastructure (RF sources, waveguide system, etc) will determine the time of test.

Where:
Probably most practical place is place close to future RFQ position. It will allow to use RFQ infrastructure (RF source, waveguides, etc.)

Who:
Somebody should take care about infrastructure .